August 1, 2003

Mr. James J. Sheppard
President and Chief Executive Officer
STP Nuclear Operating Company
South Texas Project Electric
Generating Station
P. O. Box 289
Wadsworth, TX 77483

SUBJECT: SOUTH TEXAS PROJECT, UNIT 1 - RELIEF REQUEST RR-ENG-2-33, ALTERNATIVE FLAW CHARACTERIZATION CRITERIA FOR TWO BOTTOM-MOUNTED INSTRUMENT PENETRATION WELDS (TAC NO. MB9727)

Dear Mr. Sheppard:

By letter dated June 25, 2003, as supplemented by letters dated July 3, and July 17, 2003, STP Nuclear Operating Company, the licensee, requested the U. S. Nuclear Regulatory Commission (NRC) to grant relief from the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Section XI requirements to characterize flaws in the original J-groove weld and associated buttering of two repaired bottom-mounted instrumentation (BMI) penetrations and perform successive examinations of these areas during the current 10-year inspection interval.

The NRC staff concludes that requiring the licensee to comply with the ASME XI nondestructive examination requirements is impractical. The licensee's request and supporting information as stated under Relief Request RR-ENG-2-33 for South Texas Project (STP), Unit 1, provides reasonable assurance of structural integrity of the repair. Therefore, relief is granted pursuant to Section 10 CFR 50.55a(g)(6)(i) of Title 10 of the *Code of Federal Regulations*, for STP, Unit 1, for the remainder of the second Inservice Inspection interval.

In order to facilitate the restart of the plant, the staff provided, on July 30, 2003, a verbal authorization, granting relief.

All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in this safety evaluation remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

The NRC staff's safety evaluation is enclosed.

Sincerely,

/RA/

Robert A. Gramm, Chief, Section 1
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-498

Enclosure: Safety Evaluation

cc w/encl: See next page

All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in this safety evaluation remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

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*Staff provided SE, dated July 23, 2003, with minor editorial changes was used.
** See prior concurrence

OFFICE	PDIV-1/PM	PDIV-1/PM	PDIV-1/LA	EMCB/DE*	OGC**	PDIV-1/SC
NAME	NKalyanam	RGramm for MThadani	MMcAllister	TChan	RHoefling	RGramm
DATE	8/01/03	8/01/03	8/01/03	07/18/03	07/31/03	8/01/03

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR RELIEF RR-ENG-2-33

ALTERNATIVE FLAW CHARACTERIZATION CRITERIA FOR

BOTTOM-MOUNTED INSTRUMENT PENETRATIONS #1 AND #46 WELDS

SOUTH TEXAS PROJECT NUCLEAR OPERATING COMPANY

SOUTH TEXAS PROJECT, UNIT 1

DOCKET NO. 50-498

1.0 INTRODUCTION

By letter dated June 25, 2003, as supplemented by letters dated July 3, and July 17, 2003, STP Nuclear Operating Company (STPNOC), the licensee, requested relief from the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," requirements associated with characterizing flaws in the original J-groove weld and associated buttering of two repaired bottom-mounted instrument (BMI) penetration welds.

2.0 BACKGROUND

The Inservice Inspection (ISI) of the ASME Class 1, 2, and 3 components is to be performed in accordance with Section XI of the ASME Code and applicable edition and addenda as required by Section 10 CFR 50.55a(g) of Title 10 of the *Code of Federal Regulations*, except where specific relief has been granted by the Commission pursuant to Section 10 CFR 50.55a(g)(6)(i). Section 10 CFR 50.55a(a)(3) states in part that alternatives to the requirements of paragraph (g) may be used, when authorized by the U. S. Nuclear Regulatory Commission (NRC), if the licensee demonstrates that: (i) the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Pursuant to Section 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) will meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The ISI code of record for

South Texas Project (STP), Unit 1, second 10-year ISI interval is the 1989 Edition of the ASME Code.

3.0 EVALUATION OF RELIEF REQUEST

3.1 The Items for which Relief is Requested (as stated):

Reactor Vessel BMI nozzle penetrations. There are 58 BMI nozzles welded to the bottom head of the reactor vessel. The ASME Code Class is Class 1. This relief request applies to penetrations #1 and #46 only.

3.2 Code Requirement (as stated):

Section XI, Article IWA-3000 provides standards for examination evaluation.

IWA-3100(a) states in part:

Evaluation shall be made of flaws detected during an inservice examination as required by IWB-3000 for Class 1 pressure retaining components...

IWA-3300(b) states:

Flaws shall be characterized in accordance with IWA-3310 through IWA-3390 as applicable.

Section XI, Article IWB-3000 provides acceptance standards for Class 1 components.

IWB-3420 states:

Each detected flaw or group of flaws shall be characterized by the rules of IWA-3300 to establish the dimensions of the flaws. These dimensions shall be used in conjunction with the acceptance of IWB-3500.

Section XI, Article IWB-2000 provides examination and inspection requirements for Class 1 components.

IWB-2420(b) states:

If flaw indications or relevant conditions are evaluated in accordance with IWB-3132.4 or IWB-3142.4, respectively, and the component qualifies as acceptable for continued service, the areas containing such flaw indications or relevant conditions shall be reexamined during the next three inspection periods listed in the schedules of the inspection programs of IWB-2410.

3.3 Reasons for the Request (as stated):

STP Nuclear Operating Company (STPNOC) conducted visual examinations of the reactor vessel BMI nozzle penetrations prior to startup from Unit 1 Refueling Outage 1RE11. These examinations revealed evidence of leakage in the annulus of two penetrations (Penetrations 1 and 46). Subsequent nondestructive examination (NDE) conducted from the nozzle bore of all penetrations confirmed the presence of flaws in the Alloy 600 nozzles of Penetrations 1 and 46 and verified no flaws existed in the nozzles of the other penetrations. The half-nozzle repair/replacement process has been implemented on the two flawed BMI nozzles. This process removed the lower portion of the BMI nozzle within and below the reactor vessel bottom head (RVBH) and replaced it with an Alloy 690 half-nozzle. A new pressure boundary J-groove weld was fabricated between the replacement nozzle and the RVBH outside surface. The upper portion of the Alloy 600 nozzle material remained in place, but it is no longer pressure retaining. The original J-groove weld on the RVBH inside surface became a non-structural attachment weld to the vessel. The final configuration is depicted in Figure 1 [Reference: STPNOC letter dated June 25, 2003].

The original J-groove weld was subject to an inservice inspection (ISI) VT-2 visual examination for reactor coolant leakage under both Section XI Examination Category B-P each inspection period and Examination Category B-E each inspection interval. There are three inspection periods in each ten-year inspection interval. Since the half-nozzle repair/replacement is now complete, the original J-groove weld is subject to an ISI VT-3 visual examination under Examination Category B-N-2 each inspection interval. The new J-groove weld outside the RVBH is subject to an ISI VT-2 visual examination for reactor coolant leakage under Section XI Examination Categories B-E and B-P.

Flaw initiation and/or growth in the remaining Alloy 600 nozzle material is not a concern from a code perspective since this nozzle remnant does not serve a pressure boundary or structural role. The nozzle remnant does have an operability function for the BMI thimble tubes, but any loss of material could impact the reactor vessel loose parts analysis. STPNOC has evaluated these functions and determined the nozzle remnants will continue to perform these functions.

Flaws may exist in the original J-groove weld and buttering of the repaired penetrations that cannot be characterized by NDE. The materials and configuration of the original J-groove weld and buttering do not permit characterization of flaws within these welds by available NDE technology. This relief request seeks approval for the two repaired BMI penetrations to remain in service without NDE characterization or successive examinations of potential flaws in the original J-groove weld, buttering, and adjacent RVBH base material based on a postulated flaw growth analysis and other bases as described below.

3.4 Licensee's Proposed Alternatives and Bases for Use:

Pursuant to 10 CFR 50.55a(g)(5)(iii), the licensee is seeking relief from NDE and successive examinations of potential flaws in the original J-groove weld, buttering and adjacent RVBH base materials of BMI Penetrations 1 and 46, after half-nozzle repair of the penetrations.

3.5 Licensee's Basis for Relief:

The licensee stated that visual examination of the reactor vessel BMI nozzle penetrations prior to startup revealed evidence of leakage in the annulus of two penetrations. NDE conducted from the nozzle bore of all penetrations confirmed the presence of flaws in the Alloy 600 nozzle base material of Penetrations 1 and 46, and verified no flaws existed in the nozzles of the other penetrations. The half-nozzle repair/replacement process has been implemented on the two flawed BMI nozzles.

The half-nozzle repair removed the lower portion of the BMI nozzle within and below the RVBH and replaced it with an Alloy 690 half-nozzle. A new pressure boundary J-groove weld was fabricated between the replacement nozzle and the RVBH outside surface. The upper portion of the Alloy 600 nozzle base material remains in place, but is no longer pressure retaining, according to the licensee. The original J-groove weld on the RVBH was subjected to an ISI VT-2 visual examination for reactor coolant leakage under both Section XI Examination Category B-P for each inspection period and Examination Category B-E for each inspection interval. Since the half-nozzle repair/replacement is now complete, the licensee stated the original J-groove weld is subject to an ISI VT-3 visual examination under Examination Category B-N-2 each inspection interval. The new J-groove weld outside the RVBH is subject to an ISI VT-2 visual examination for reactor coolant leakage under Section XI Examination Categories B-E and B-P.

The licensee stated that flaws may exist in the original J-groove weld and buttering of the repaired penetration, but these hypothetical flaws cannot be characterized by NDE. The licensee stated that due to the materials and geometry of the weld area, the current state of NDE technology is not adequate to detect and characterize flaws in these welds. Therefore, it is not practical to comply with the ASME Section XI Code requirements cited above for flaw characterization and acceptance evaluation. The licensee stated that a flaw growth evaluation of these welds, and a stress and fatigue analysis of the modified configuration, combined with industry experience in primary water stress corrosion cracking (PWSCC) growth in low alloy materials, provide an alternative basis for demonstrating the structural integrity of the subject welds.

The licensee indicated the original BMI J-groove weld configuration is extremely difficult to examine with ultrasonic examination (UT) techniques from inside the vessel due to the compound curvature of the RVBH. If UT examination of the J-groove weld were attempted from inside the vessel, both the cladding interface and weld buttering interface would provide an acoustic mismatch that would severely limit a confident examination of the J-groove weld material. Additionally, access to the RVBH inside surface for UT examination of the J-groove weld would be a hardship because access can only be obtained by removing the fuel elements and vessel internals. If a UT examination of the original J-groove weld were attempted from the outside surface of the RVBH, the J-groove buttering interface would provide an acoustic mismatch that would severely limit the UT examination. The UT examination would encounter problems due to the compound curvature of the head and would require long examination distances for interrogation of radial-axial oriented flaws at the opposite (inside) surface. These conditions would make accurate detection, characterization, and sizing of flaws very difficult. Additionally, UT examinations performed from the RVBH outside surface would be performed in a high radiation area.

Radiography of this area is impractical due to the inability to position either a source or film inside the RVBH. Dye penetrant, magnetic particle, and eddy current examinations would not provide useful volumetric information.

The licensee's position is that it is impractical and the technology does not exist to characterize flaw geometries that may remain in the remnant J-groove weld, buttering, or adjacent RVBH base material. Another issue is the dissimilar metal interface between the Ni-Cr-Fe weld and the low alloy steel closure head which increases the difficulty of UT. Based on these physical limitations, the licensee went on to state that the inability to characterize the flaws will continue in the foreseeable future, making successive examinations impractical.

The licensee's alternative consists of ASME Section XI calculations that were performed to show that any flaws that may remain in the remnant J-groove weld are acceptable for continued service. The licensee has postulated "worst case" flaws in these welds that extend from the J-groove weld surface to the butter-to-RVBH base material interface. Based on extensive industry experience, the licensee indicated there are no known cases where flaws initiating in an Alloy 82/182 weld have propagated into the ferritic base material. An analysis of the modified BMI nozzle configuration was performed using a three-dimensional model of a BMI nozzle located at the most severe hillside orientation. The general purpose finite element software program ANSYS was used for the analysis. The calculated stresses are compared to ASME Code Section III, NB-3000, criteria for design conditions; normal, operating, and upset conditions; emergency conditions; faulted conditions; and, testing conditions.

An ASME Section XI flaw growth analysis has been performed to show that the postulated flaws are acceptable for at least 40 additional years of plant operation. The only driving mechanism is fatigue crack growth. The evaluation assumed a radial-axial crack with a length equal to the partial penetration weld preparation depth.

The licensee indicated a fracture mechanics evaluation has verified that degraded J-groove weld metal and buttering could be left in the vessel, with no examination to size any flaws that might remain following the repair. Since the hoop stresses in the J-groove weld are generally about two times the axial stress at the same location, the preferential direction for cracking would be axially, or radially with respect to the nozzle. The licensee postulated that a radial-axial crack in the Alloy 182 weld metal would propagate due to PWSCC, through the weld and butter, to the interface with the low alloy reactor pressure vessel head and that it would blunt and arrest at the butter-to-head interface. They indicated that ductile crack growth through the Alloy 182 metal would tend to relieve the residual stresses in the weld as the crack grew to its final size and blunted.

Although residual stresses in the RPV head metal are low, it was assumed that a small flaw could initiate in the low alloy steel metal and grow by fatigue. The licensee stated that a small flaw in the RPV head would combine with a large stress corrosion crack in the weld to form a radial corner flaw that would propagate into the low alloy steel RPV head by fatigue crack growth under cyclic loading conditions associated with heatup and cooldown and other applicable transients.

Flaw evaluations were performed for a postulated radial corner crack on the vessel head penetration, where stresses are the highest and the radial distance from the inside corner to the low alloy steel base material is the greatest. Hoop stresses were used because they are perpendicular to the plane of the crack. Fatigue crack growth, calculated for the remaining operation life, was small and the final flaw size was shown to meet the fracture toughness requirements of the ASME Code using an upper shelf value of 200 ksi $\sqrt{}$inch for ferritic steels.

The licensee stated that it may remove boat samples from the BMI Alloy 600 nozzle base material of Penetrations 1 and 46 to obtain portions of known flaws in support of the root cause determination. If boat samples are removed, they will be extracted from inside the reactor vessel from the water side of the J-groove weld. The boat sample will remove part of the J-groove weld and part of the Alloy 600 nozzle base material containing the flaw. The potential boat sample cavities will be left in the J-groove weld and nozzle material without repairing these cavities by welding. The licensee will assure the effect of these potential boat sample cavities meet Section III stress analysis and Section XI flaw growth analysis requirements.

Finally, the licensee indicated that subsequent NDE of the J-groove weld and buttering to satisfy successive examination requirements is impractical. The postulated flaws are not in a pressure-retaining weld and based on industry experience, they would arrest at the butter-to-low alloy steel base material interface. The licensee indicated that it has analyzed a postulated flaw as acceptable for continued service based on the flaw growing to the butter-to-low alloy steel base material interface and blunting. It has also analyzed postulated fatigue cracks in the RVBH base material in conjunction with PWSCC in the J-groove weld and buttering, and has determined that the Section XI evaluation criteria are satisfied.

3.6 Staff Evaluation

IWA-3300(a) of the 1989 Edition of the ASME Code states that flaws detected by the preservice and inservice examinations shall be sized by the bounding rectangle or square for the purpose of description and dimensioning. IWA-3300(b) of the ASME Code states that flaws shall be characterized in accordance with IWA-3310 through IWA-3390 as applicable. IWB-3132.4(a) of the ASME Code states that components whose volumetric or surface examinations reveal flaws that exceed the acceptance standards listed in Table IWB-3410-1 shall be acceptable for service without the flaw removal, repair, or replacement if an analytical evaluation, as described in IWB-3600, meets the acceptance criteria of IWB-3600.

The repair plan consists of performing a half-nozzle repair by machining out the bottom portion of BMI nozzle, inserting a new section approximately halfway between the inner and outer diameter of the RVBH, and welding the new nozzle section to an Alloy 690 weld pad which is in contact with the RVBH. This repair action changes the remnant J-groove weld to a non-pressure retaining attachment to the interior of the RVBH, Examination Category B-N-2. The newly deposited repair weld area is now considered the pressure retaining weld and examined as Examination Category B-P and B-E under the ISI program. The licensee’s alternative is to eliminate the ASME Code requirements of characterization and successive inspections of defects that may remain in the remnant J-groove weld.

The licensee's position is that the original J-groove weld configuration is extremely difficult to UT due to the compound curvature of the head and fillet radius. These conditions preclude ultrasonic coupling to the RPV head and control of the sound beam in order to perform flaw sizing with reasonable confidence in measuring the flaw dimension from the inner surface of the head. They indicated it is impractical and the technology does not exist to characterize flaw geometries that may exist in the J-groove weld. Another issue is the dissimilar metal interface between the Ni-Cr-Fe weld and the low alloy steel closure head which increases the difficulty of UT. Impediments to examination from the outer surface of the RPV head exist due to proximity of adjacent nozzle penetrations according to the licensee. Based on these physical limitations, the licensee went on to state that the inability to characterize the flaws will continue in the foreseeable future, making subsequent examinations impractical.

The NRC staff agrees that examination of any flaws in the J-groove weld region is impractical due to both the configuration and the metallurgical structure of the J-groove weld. The angle of incidence from the outer surface of the closure head base material does not permit perpendicular interrogation by ultrasonic shear wave techniques of circumferentially-oriented flaws and the physical proximity of the nozzle does not allow for longitudinal scrutiny of the area of interest. If examination of the J-groove weld were to be attempted from the inner diameter of the head, the cladding would provide an acoustic interface which would severely limit a confident examination of the weld material. Radiography of this area is impractical because circumferentially-oriented flaws are perpendicular to gamma and x-rays. Dye penetrant and magnetic particle examination will not provide useful volumetric information since these are surface techniques. Secondly, the highly attenuative, coarse-grained metallurgical structure of the Alloy 600 J-groove weld does not lend itself to ultrasonic examination based on many years of industry experience with this material. Based on the discussion above, the NRC staff concludes that compliance with the flaw characterization and successive inspection requirements of the ASME Code for the remnant J-groove weld is impractical.

In its relief request, the licensee provided information that indicated they have performed the analyses of a postulated "worst case" flaw that may remain in the remnant J-groove weld. The analyses allowed them to conclude that the postulated flaw would grow to the cladding-ferritic interface and blunt. Fatigue crack growth calculations showed that the final flaw size will not exceed the maximum allowable considering the fracture toughness requirements of the ASME Code using an upper shelf value of 200 ksi√inch for ferritic materials. Based on the information provided by the licensee and published data, the staff concludes that there is reasonable assurance of the continued structural integrity of the RVBH within the remaining service life of the RVBH.

In its supplemental letter dated July 3, 2003, the licensee indicated that it would perform successive inspections on repaired/replaced BMI penetration nozzles, weld pads, and J-groove welds that establish a new pressure boundary. Repaired/replaced BMI nozzles, weld pads, and J-groove welds will receive a bare metal visual examination each refueling outage in accordance with its Boric Acid Walkdown procedure. In its supplemental letter dated July 17, 2003, the licensee indicated that it will perform UT examination of the RVBH BMI bore hole areas around one of the two BMI penetrations for the next two alternate refueling outages to confirm there is no indication of RVBH base material wastage from reactor coolant system water in the annulus region of the repaired penetration.

The NRC staff concludes that characterization of flaws that may exist in the thimble guide tubes penetration J-groove welds and conformance to the successive inspection requirements would be impractical. In addition, the rationale and information provided by the licensee, under the analyses described above, provide reasonable assurance that no significant crack growth will occur in the RVBH pressure boundary and the structural integrity of the repair weld will be maintained for an extended period of time. Finally, the commitments to perform additional UT and Bare Metal Visual inspections provide reasonable assurance of the continued structural integrity of the RVBH and is therefore, acceptable.

4.0 Conclusion

The NRC staff concludes that requiring the licensee to comply with the ASME XI NDE requirements is impractical. Therefore, the licensee's request and supporting information as stated under Relief Request RR-ENG-2-33 for STP, Unit 1, provides reasonable assurance of structural integrity of the repair. Therefore, relief is granted pursuant to 10 CFR 50.55a(g)(6)(i) for STP, Unit 1, for the remainder of the second ISI interval. This grant of relief is authorized by law and will not endanger life or property or the common defense and security and is otherwise in the public interest giving due consideration to the burden upon the licensee that could result if the requirements were imposed on the facility. All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in this safety evaluation remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: T. K. Steingass

Date: August 1, 2003

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